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SPECIFICATION FOR CARBON AND LOW ALLOY STEEL FORGINGS FOR FIRED AND UNFIRED PRESSURE VESSELS

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SPECIFICATION FOR CARBON AND LOW ALLOY STEEL FORGINGS FOR FIRED AND UNFIRED PRESSURE VESSELS

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Indian Standard

SPECIFICATION FOR CARBON AND LOW ALLOY STEEL FORGINGS FOR FIRED AND UNFIRED PRESSURE VESSELS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 10 December 1980, after the draft finalized by the Steel Forgings Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 The steel forgings covered in this standard were generally regarded as weldable. However, the general suitability of the steels for use with various welding processes cannot be guaranteed as the behaviour of the steel during and after welding is dependant not only upon the steel but also on the welding conditions and final use.

0.3 For the benefit of the purchaser informative appendices (*see* Appendices A and B) giving the information to be furnished by the purchaser while ordering for the steel forgings as also the details to be included in the test certificate by the manufacturer while supplying the forgings, have been included.

0.4 In the preparation of this standard, assistance has been derived from the following standards:

BS 1503:1969 Steels for fired and unfired pressure vessels, forgings. British Standards Institution.

ASTM A 105-1977 Forgings, carbon steel for piping components. American Society for Testing and Materials

ASTM A 182-1978 Forged or rolled alloy steel pipe flanges, forged fittings, and valves and parts for high temperature services. American Society for Testing and Materials

ASTM A 336-1978 Alloy steel forgings for seamless drums, heads and other pressure vessel components. American Society for Testing and Materials.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers six grades of carbon and low alloy steel forgings used in the construction of fired and unfired pressure vessels.

1.1.1 The term 'forgings' used in this standard shall include forged fittings, covers, heads, component sections or complete vessels intended for containment of gaseous or liquid material under pressure.

2. TERMINOLOGY

2.1 For the purpose of this standard the definitions given in IS : 1956† and its relevant parts shall apply.

3. SUPPLY OF MATERIAL

3.1 General requirements relating to the supply of carbon and low alloy steel forgings shall be as laid down in IS : 1387-1967‡.

4. MANUFACTURE

4.1 All forgings shall be manufactured from fully killed steel produced by open hearth, electric, basic oxygen or any other approved process. If required, the purchaser may be informed of the steel making process. In case steel is made by basic oxygen process, the nitrogen content shall be restricted to 0·007 percent maximum.

4.1.1 *Discard* — Sufficient discard shall be made from each ingot to secure freedom from piping and excessive segregation.

4.1.2 *Forgings Made from Rolled Products* — Unless otherwise specified on the enquiry and order, the forgings may be made from rolled products subject to the requirements of **4.1.5**.

4.1.3 *Hot Working* — The amount of hot working shall be such as to ensure complete soundness and adequate uniformity of structure and mechanical properties.

4.1.3.1 Forging shall be brought as nearly as practicable to the finished shape and size by hot working and, where practicable, shall be so worked as to cause metal flow in the direction most favourable for resisting the service stresses which it is recommended should be made known to the manufacturer.

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*Rules for rounding off numerical values (*revise*).

†Glossary of terms relating to iron and steel:
Part I General metallurgy, heat treatment and testing
Part II Steel making
Part III Hot rolled steel products (excluding sheet and strip)
Part VI Forging (including drop forging)

‡General requirements for the supply of metallurgical materials (*first revision*).

4.1.3.2 Alternatively, by agreement between the purchaser and the manufacturer, a cold forging process may be used.

4.1.4 *Forging Reduction*

4.1.4.1 *Hollow forgings* — Alternatively, solid ingots may be used which are subsequently upset, purchased/purchased and enlarged to make hollow forgings. Total forging reduction in that case should not be less than 2·5:1.

4.1.4.2 *Solid forgings* — Unless otherwise agreed for solid forgings the total forging reduction of any part of the forging shall be not less than 3:1 where the length at any diameter is greater than the diameter. In case any part of the forging has length at any diameter less than the diameter, the forging reduction at that part shall be not less than 1·5 : 1.

4.1.4.3 *Solid forging subsequently bored* — For solid forgings subsequently bored with a hole of diameter greater than one-fifth of the overall diameter of the forging, the total forging reduction shall not be less than 2 : 1. In case any part of the forging has length at any diameter less than the diameter, the forging reduction at that part shall be not less than 1·5 : 1.

4.1.5 *Forgings Made from Rolled Products* — For forgings made from rolled products, the reduction in area from the ingot to the finished forging shall be not less than 4 : 1 in the case of the forgings made from products rolled with ingots cast with the larger cross section upper most and with efficient reeder heads, and not less than 6 : 1 for forgings made from products from other types of ingots.

5. CHEMICAL COMPOSITION

5.1 Ladle Analysis — The ladle analysis of the steel when made in accordance with relevant parts of IS : 228* shall be as given in Table 1.

---

*Methods of chemical analysis of steels:

Part I Determination of carbon by volumetric method (for carbon $\geqslant$ 0·1 percent) (*second revision*)

Part II Determination of manganese in plain carbon and low alloy steels by arsenite method (*second revision*)

Part III Determination of phosphorus by alkalimetric method (*second revision*)

Part IV Determination of carbon by gravimetric method (for carbon $\geqslant$ 0·1 percent) (*second revision*)

Part V Determination of nickel by dimethylglyoxime (gravimetric) method (for nickel $\geqslant$ 0·5 percent) (*second revision*)

Part VI Determination of chromium by persulphate oxidation method (for chromium $\geqslant$ 0·5 percent) (*second revision*)

Part VII Determination of molybdenum by α-benzoinoxime method (for molybdenum $>$ 1 percent) (*second revision*)

Part VIII Determination of silicon by the gravimetric method (for silicon $\geqslant$ 0·1 percent) (*second revision*)

Part IX Determination of sulphur in plain carbon steels by evolution method (*second revision*)

Part X Determination of molybdenum by thiocyanate (photometric) method (for molybdenum up to 1 percent) in low and high alloy steels (*second revision*)

Part XII Determination of manganese by periodate (photometric) method in low and high alloy steels (for manganese up to 2 percent) (*second revision*)

TABLE 1 CHEMICAL COMPOSITION OF CARBON AND LOW ALLOY STEEL FORGINGS

(*Clause* 5.1)

GRADE	DESIGNATION [*See* IS : 1762 (PART I)-1974*]	PERCENT									
		C	Si	Mn	S	P	Cr	Mo	V	Ni	Al
					Max	*Max*					
1.	20C6	0·15-0·25	0·10-0·35	0·40-0·80	0·045	0·040	—	—	—	—	—
2.	15Mn5	0·20 *Max*	0·15-0·35	0·90-1·70	0·045	0·040	—	—	—	—	0·015 *Min*
3.	12Cr4Mo6	0·08-0·15	0·10-0·35	0·30-0·80	0·040	0·04	0·70-1·10	0·45-0·65	—	—	0·02 *Max*
4.	14Cr2Mo6V3	0·10-0·18	0·15-0·35	0·30-0·60	0·040	0·04	0·30-0·60	0·50-0·65	0·25-0·35	—	—
5.	12Cr9Mo10	0·08-0·15	0·10-0·35	0·40-0·70	0·040	0·04	2·0-2·5	0·90-1·10	—	—	0·02 *Max*
6.	10Ni14	0·15 *Max*	0·10-0·35	0·30-0·80	0·030	0·025	—	—	—	3·25-3·75	0·015 *Min*

*Code for designation of steel: Part I Based on letter symbols (*first revision*).

5.2 Check Analysis — The permissible variations in case of check analysis from the specified limits shall be as given in Table 2.

5.2.1 Check analysis shall be carried out on the finished forgings. The number of samples on which analysis has to be carried out shall be as agreed to between the purchaser and the manufacturer. However, a sampling plan is given in Appendix C for guidance.

5.3 When the purchaser considers that the level of particular residual elements, not already specified in this standard, is important in relation to the properties of the steel, an upper limit of these residual elements may be imposed by agreement with the manufacturer and shall be stated in the order.

6. HEAT TREATMENT

6.1 All forgings shall be heat treated by annealing or normalizing or normalizing and tempering. The recommended temperatures for heat treatment are given in Table 3.

6.1.1 Forging may be liquid quenched and tempered as agreed to between the purchaser and the manufacturer.

6.1.2 Appropriate soaking time should be used by the manufacturer for the above heat treatment.

6.2 Heat Treatment of Test Samples in Relation to Welding and Stress Relieving Procedures

6.2.1 *Forgings Stress Relieved by the Supplier* — If the forgings form part of a welded vessel or structure, which is stress-relieved by the supplier, the test samples shall receive all the heat treatments applied to the forgings as requred in **6.1** and shall either:

a) be subjected with the forgings or fabricated vessel to the stress relieving heat treatment, or

b) be separately subjected to a stress relieving treatment which is calculated to produce a similar effect on the mechanical properties as that applied to the vessel or structure.

6.2.2 *Forgings to be Stress Relieved by the Purchaser* — Where the purchaser intends to incorporate the forging or fabrication in a welding vessel of structure and will apply a stress-relief heat-treatment test samples which have received heat treatments referred to in **6.1** or **6.2** plus **6.2.1** shall also be subjected by the supplier to a stress-relief heat-treatment which is calculated to produce a similar effect on the mechanical properties as the stress-relief heat-treatment to be applied to the welded vessel or structure by the purchaser.

TABLE 2 PERMISSIBLE VARIATION IN PRODUCT ANALYSIS

(*Clause* 5.2)

ELEMENT	UNIT OF *Max* SPECIFIED RANGE PERCENT	PERMISSIBLE VARIATION OVER THE SPECIFIED MAXIMUM LIMIT OR UNDER THE SPECIFIED MINIMUM LIMIT, PERCENT CROSS-SECTIONAL AREA					
		Up to and Including 650 cm²	Over 650 Up to 1 300 cm² Including	Over 1 300 Up to 2 600 cm² Including	Over 2 600 Up to 5 200 cm² Including	Over 5 200 Up to 10 400 cm² Including	Over 10 400 cm²
Carbon	to 0·10 incl	0·01	0·01	0·01	0·01	0·01	0·01
	over 0·10 to 0·25 incl	0·02	0·03	0·03	0·04	0·05	0·05
Manganese	to 0·9 incl	0·03	0·04	0·05	0·06	0·07	0·08
	over 0·9	0·06	0·06	0·07	0·08	0·08	0·09
Sulphur	to 0·03 incl	0·005	0·005	0·005	0·005	0·006	0·006
	over 0·03	0·008	0·010	0·010	0·010	0·015	0·015
Phosphorus	to 0·040 incl	0·008	0·008	0·010	0·010	0·010	0·015
Silicon	to 0·35 incl	0·02	0·03	0·04	0·04	0·05	0·06
Nickel	to 1·00 incl	0·03	0·03	0·03	0·03	0·03	0·03
	over 1·00 to 2·00 incl	0·05	0·05	0·05	0·05	0·05	0·05
	over 2·00	0·07	0·07	0·07	0·07	0·07	0·07
Chromium	to 0·90 incl	0·03	0·04	0·04	0·05	0·05	0·06
	over 0·90 to 2·10 incl	0·05	0·06	0·06	0·07	0·07	0·08
	over 2·10	0·10	0·10	0·12	0·14	0·15	0·16
Molybdenum	to 0·20 incl	0·01	0·02	0·02	0·02	0·03	0·03
	over 0·20 to 0·40 incl	0·02	0·03	0·03	0·03	0·04	0·04
	over 0·40	0·03	0·04	0·05	0·06	0·07	0·08

NOTE — Product cross-sectional area taken at right angles to the axis of the original ingot or billet is defined as:

i) Maximum cross-sectional area of rough machined forging excluding boring,
ii) Maximum cross-sectional area of the unmachined forging, or
iii) Maximum cross-sectional area of the billet, bloom or slab.

NOTE 1 — If any additional or unforeseen stress-relief heat treatment has to be applied by the purchaser the stress-relief heat treatment temperature should not exceed the temperature of the final heat treatment that is, either tempering or stress-relief applied by the supplier to the test samples.

NOTE 2 — If so desired, the purchaser may be supplied with additional test samples, which have been cut from the forgings after heat treatment in accordance with **6.2** and if applicable **6.2.1** with a view to subjecting these test samples to the final stress-relief heat treatment and subsequent mechanical testing for information purposes.

TABLE 3 RECOMMENDED TEMPERATURES FOR HEAT TREATMENT

(*Clause* 6.1)

GRADE	NORMALIZING/ANNEALING TEMPERATURE RANGE (°C)	TEMPERING TEMPERATURE *Min* (°C)
1	840-930	590
2	840-930	590
3	890-940	620
4	940-980	660
5	930-1 000	650
6	850-900	580

7. FREEDOM FROM DEFECTS

7.1 Forgings shall be inspected and be free from injurious defects like segregations, cracks, lamination or flaws as might preclude their use for the purpose for which they are intended.

7.2 Defects in forgings shall not be repaired without previous sanction of the purchaser or his representative.

7.3 In case test for internal soundness is desired reference shall be made to **10.2**.

7.4 In the event of forgings proving defective during subsequent operations, steel forgings shall be regarded as not complying with this Indian Standard notwithstanding previous certificate of satisfactory testing.

8. TOLERANCES

8.1 Forgings shall conform to its sizes and shapes specified by the purchaser.

8.2 The purchaser's drawing shall indicate the dimensions and the dimensional tolerances as well as the surface finishes required on the forgings. Surface scales shall be removed by abrasive blasting or other approved process to permit inspection.

8.3 The number of samples and criteria for conformity for size requirements is given in Appendix C.

9. MECHANICAL TESTS

9.1 Number of Test Samples

9.1.1 The number of test samples and criteria for conformity for mechanical tests is given in Appendix C.

9.2 Selection and Preparation of Test Samples

9.2.1 *Selection of Test Samples* — Test samples in the form of rings or prolongations of a minimum dimension of 50 mm shall be taken from one or both ends of open vessels or from the open end of vessels solid at one end.

In the case of closed hollow vessels including headers, the test samples may be cut off before closing in which case they shall be heat-treated with the vessels and shall be so positioned with respect to the vessels that they receive representative heat treatment.

In the case of open hollow vessels, the test samples shall be cut off after the completion of the heat treatment.

In other cases, the test sample shall be cut from one of the forgings, or additional material of sufficient size shall be provided. For instance, in the case of pushed flanges the punchings may be used as test samples, in which case the indentity of the material of the punching with that of the flange shall be evidenced in an adequate manner. Alternatively, a piece of the billet or bar from which the forgings were made can be used, provided it is given approximately the same degree of hot work. If separate test samples are used, they shall be heat-treated with the finished forgings.

If these procedures are not appropriate the method of providing the test samples shall be as agreed to between the manufacturer and the purchaser and stated in the order.

9.2.2 Except as specified in **6.2.1** or otherwise agreed to between the purchaser and the manufacturer, the test samples and test pieces shall not be subjected to any further heat treatment or hot or cold work prior to testing.

9.2.3 Test samples shall be cut either in the direction of or transversely on the direction of principal grain flow, as agreed to between the manufacturer and the purchaser. The longitudinal test values apply to samples cut in the direction of principal grain flow. The transverse test values of samples cut transversely to the direction of principal grain flow, is a subject of agreement.

Where there is doubt regarding the direction of principal grain flow, for example, in a flange formed by upsetting a billet the direction from which test samples are cut and the elongation and bend test requirement to be met shall be agreed to between the purchaser and the manufacturer.

9.3 Preparation of Test Pieces

9.3.1 Except as otherwise agreed, the test pieces shall be prepared from the test samples from a sub-surface position, that is with the axis of the test piece about 12·5 mm below the outer surface of the forging.

9.4 Tensile Test

9.4.1 The tensile strength, yield strength and percentage elongation, when determined in accordance with IS : 1608-1972* shall conform to the requirements specified in Table 4.

9.4.2 Should a tensile test piece break outside the middle half of its gauge length and the percentage elongation obtained is less than the specified, the test may be discarded at the option of the manufacturer and another test made from the sample representing the same lot.

9.5 Bend Test

9.5.1 Bend test piece shall be of rectangular section 25·0 mm wide, 20 mm thick or proportionally smaller in the case of smaller forgings. The corners may be slightly rounded to a radius not exceeding 1·6 mm.

9.5.2 Bend test shall be carried out in accordance with IS : 1599-1974†. The test piece shall be capable of being bent cold without fracture to the angle given in Table 4 round a mandrel of diameter specified in Table 4.

9.6 Charpy Impact Test

9.6.1 *Room Temperature Test*

9.6.1.1 The notched bar impact test at room temperature shall be carried out in accordance with IS : 1499-1977‡.

9.6.1.2 Unless otherwise specified in the order or contract, the impact value shall be determined by the average of three test specimens next to one another in the test sample. If the three tests are made, the average value should comply with the requirements mentioned in Table 4 and one individual value may be below the specified minimum value provided it is not less than 75 percent of that value.

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*Method for tensile testing of steel products (*first revision*).

†Method for bend test for steel products other than sheet, strip, wire and tube (*first revision*).

‡Method for Charpy impact test (U-notch) for metals (*first revision*).

TABLE 4 MECHANICAL PROPERTIES OF STEEL FORGINGS

(*Clauses* 9.4.1, 9.5.2, 9.6.1.2 *and* 9.6.1.4)

PROPERTY	GRADE OF STEEL					
	1	2	3	4	5	6
i) Tensile strength, N/mm^2	490 to 610	490 to 610	410 to 560	460 to 610	540 to 690	490 to 640
ii) Yield strength, N/mm^2, *Min*	265	265	255	275	335	275
iii) Elongation, percent, on gauge length $5 \cdot 65\sqrt{A}$, *Min*	16	16	18	16	15	16
iv) Impact value, Joules, *Min*	60	—	50	40	40	—
v) Bend Test						
a) Angle of bend	180°	180°	180°	180°	180°	180°
b) Diameter of the mandrel	t*	t*	$2t$*	$3t$*	$2t$*	$2t$*

NOTE — The mechanical properties specified relate to longitudinal test pieces cut in the direction of principal grain flow. The reduction in mechanical properties for test pieces cut transversely to the direction of principal grain flow is a subject of agreement between the purchaser and the manufacturer.

*Thickness or diameter of test piece.

9.6.1.3 The axis of the notches in all notched bar specimens shall be normal to the nearest surface of the forgings.

9.6.1.4 The minimum average impact value at room temperature for various grades of steel are given in Table 4.

9.6.2 *Low Temperature Impact Tests*

9.6.2.1 For the steel types, which have specified low temperature properties, the minimum longitudinal charpy V notch impact value, shall comply with values given in Table 5.

TABLE 5 LOW TEMPERATURE CHARPY V-NOTCH LONGITUDINAL IMPACT VALUES IN JOULES

TEMPERATURE	GRADE 2		GRADE 6	
	Minimum Average Value	Minimum Individual Value	Minimum Average Value	Minimum Individual Value
0°C	28	21	—	—
−10°C	28	21	—	—
−15°C	28	21	—	—
−30°C	28	21	41	35
−50°C	28	21	41	35
−75°C	—	—	28	21
−100°C	—	—	21	14

9.6.2.2 Low temperature impact test on longitudinal test specimen shall be carried out as per IS : 1757-1973* at temperature specified in the enquiry and order.

9.6.2.3 If the specified minimum average value and the individual value are not obtained in the first tests, repeat tests shall be carried out on the three new longitudinal specimens taken from the same test piece. The new average value of the retest and original test should meet the requirements of Table 4 and also the individual value of the retest should satisfy Table 5.

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*Method for beam impact test (V-notch) on steel (*first revision*).

9.7 Elevated Temperature Properties

9.7.1 If required by the purchaser, 0·2 percent proof stress at elevated temperature when determined in accordance with IS : 4713-1968* shall be as given in Table 6.

TABLE 6 0·2 PERCENT PROOF STRESS AT ELEVATED TEMPERATURE FOR STEEL FORGINGS

GRADE	0·2 PERCENT PROOF STRESS AT °C (N/mm²), *Min*						
	200	250	300	350	400	450	500
1	200	180	150	130	110	90	—
2	170	160	150	140	140	130	—
3	200	180	160	140	140	130	130
4	290	270	250	240	230	220	210
5	330	320	320	320	310	290	270
6	—	—	—	—	—	—	—

NOTE — For Grade 6 steel values shall be included later as no data are available at present.

9.7.2 The tentative values for the average for rupture in 1 00 000 hours (SR) are given in Table 7 for information only.

10. ADDITIONAL TESTS

10.1 Hydrostatic Test — If so specified in the contract or order, the forgings shall be tested by the manufacturer to a hydrostatic test pressure which may be agreed upon by the purchaser and the manufacturer. In no case, however, shall the nominal stress produced by the hydrostatic test exceed 90 percent of the specified minimum room temperature yield stress. Test pressure shall be maintained for sufficient time to indicate that there are no leaks in the forgings.

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*Method for determination of lower yield stress, proof stress and proving test for steel at elevated temperatures.

TABLE 7 AVERAGE STRESSES FOR RUPTURE IN 100 000 HOURS FOR VARIOUS GRADES OF STEEL

(*Clause* 9.7.2)

GRADE	AVERAGE RUPTURE STRESSES IN N/mm^2 AT °C																				
	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590	600
1	120	100	90	70	60	50	50	40	30	30	20	—	—	—	—	—	—	—	—	—	—
2	160	140	120	110	90	80	60	50	40	30	30	—	—	—	—	—	—	—	—	—	—
3	—	—	—	—	—	310	270	240	200	170	140	110	90	70	50	40	30	20	10	—	—
4	—	—	—	—	—	—	250	220	200	180	160	140	130	110	90	80	70	—	—	—	—
5	—	—	—	—	—	—	—	—	200	180	160	140	120	100	90	80	60	50	40	30	30

NOTE — Grade 6 steel is meant for low temperature application only.

10.2 Non-destructive Testing — If testing of soundness such as radiography ultrasonics, magnetic particle detection or dye penetrants is specified by the purchaser, a special agreement at the time of order or contract is necessary. This shall include all details of the test procedure as well as the basis for acceptance.

10.3 When required, by the order or contract, a sample forging may be sectioned and etched to show flow lines and the condition as regards internal imperfection. In such cases the question of acceptable and unacceptable character of the metal flow shall be a subject of agreement between the supplier and the purchaser.

10.4 Other tests, not hereinfore mentioned, may be agreed upon at the time of the order or contract.

11. MARKING

11.1 Unless agreed otherwise, each forging shall be legibly low-stress stamped with the grade of material, cast number or identification mark and the trade mark of the manufacturer.

11.1.1 When the forgings are ordered in fully machined condition, the identification marks shall be transferred in the presence of the purchaser after full machining.

11.1.2 The forgings may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

APPENDIX A

(*Clause* 0.3)

INFORMATION TO BE FURNISHED BY THE PURCHASER

A-1. BASIS FOR ORDER

A-1.1 While placing an order for the steel forgings covered by this Indian Standard, the purchaser should specify clearly the following:

a) Grade of material;
b) Description regarding shape and size including the detailed drawings;
c) Condition of delivery including surface finish;
d) Tests required;
e) Method of manufacture;
f) Any special requirements; and
g) Test report, if required.

APPENDIX B

(*Clause* 0.3)

TEST CERTIFICATE TO BE SUPPLIED BY THE MANUFACTURER

B-1. If required, the manufacturer should furnish a test certificate containing the following details:

a) Manufacturer's name or symbol;
b) Process of manufacture;
c) Batch number;
d) Grade of material;
e) Results of various tests; and
f) Specimen number.

APPENDIX C

(*Clauses* 5.2.1, 8.3 *and* 9.1.1)

SCALE OF SAMPLING AND CRITERIA FOR CONFORMITY

C-1. LOT

C-1.1 The total number of forgings of the same type and size originating from the same cast and having been produced under similar conditions of manufacture.

C-1.1.1 Samples shall be selected and tested for each lot separately for ascertaining their conformity to the requirements of the relevant specification.

C-2. SCALE OF SAMPLING

C-2.1 Dimensional Characteristics

C-2.1.1 All the large and special forgings shall be inspected individually for dimensional characteristics which are important. Only those forgings which are found to be satisfactory shall be accepted.

C-2.1.2 In the case of general forgings the number of forgings to be selected from each lot shall be in accordance with col 1 and 2 of Table 8.

TABLE 8 SCALE OF SAMPLING AND PERMISSIBLE NUMBER OF DEFECTIVES FOR DIMENSIONAL CHARACTERISTICS

NUMBER OF FORGINGS IN THE LOT (1)	SAMPLE SIZE (2)	PERMISSIBLE NUMBER OF DEFECTIVES (3)
Up to 15	3	0
16 ,, 25	5	0
26 ,, 50	8	0
51 ,, 100	13	0
101 ,, 150	20	0
151 ,, 300	32	1
301 ,, 500	50	2
501 ,, 1 000	80	3
1 001 ,, 3 000	125	5
3 001 ,, 10 000	200	7
10 001 and above	315	10

C-2.1.2.1 The forgings shall be selected at random from the lot. For this purpose procedure is given IS : 4905-1968* shall be followed.

C-2.1.3 Each forging selected according to col 1 and 2 of Table 1 shall be inspected for dimensional requirements. Any forging failing to meet the requirements shall be called a defective. If the number of defectives found in the sample is less than or equal to the corresponding permissible number of defectives (*see* col 3), the lot shall be considered as conforming to the dimensional requirements of the relevant specification, otherwise not.

C-2.2 Chemical Characteristics

C-2.2.1 The lot which has been found satisfactory with respect to dimensional requirements shall be tested for chemical analysis. The number of forgings required for this purpose shall be taken at random in accordance with col 1 and 2 of Table 9. This may be taken from those forgings which have been found conforming to dimensional requirements.

TABLE 9 SCALE OF SAMPLING FOR CHEMICAL ANALYSIS

NUMBER OF FORGINGS (1)	NUMBER OF FORGINGS TO BE SELECTED (2)
Up to 50	2
51 ,, 150	3
151 ,, 500	5
501 and above	8

NOTE — If there is one forging in a cast, one sample shall be taken.

C-2.2.2 The lot shall be considered as complying with the requirements of various chemical properties, if the analysis made on the samples conform to the requirements of the relevant specifications.

C-2.3 Mechanical Properties

C-2.3.1 The lot which has been found satisfactory for dimensional and chemical analysis shall next be tested for physical properties like tensile strength, bend test, impact test.

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*Methods for random sampling.

C-2.3.2 The number of forgings required for this purpose shall be taken at random from those forgings already drawn in accordance with col 1 and 2 of Table 8.

C-2.3.3 From each of the forgings so selected, the required number of test specimen shall be prepared for conducting physical tests specified. The lot shall be considered as conforming to these requirements if none of the forgings selected fails to meet any of the requirements.

C-2.4 The lot shall be considered as conforming to the specification if **C-2.1.3**, **C-2.2.2** and **C-2.3.3** are satisfied.

(*Continued from page* 2)

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Shri R. N. Mahendru	Bharat Heavy Electricals Ltd, Hardwar
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Shri S. Mazumdar	Foundry Forge Plant, Heavy Engineering Corporation Ltd, Ranchi
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Shri M. Mistri (*Alternate*)	

INDIAN STANDARDS
ON
STEEL FORGINGS

IS:	
1875-1978	Carbon steel billets, blooms and slabs for forgings (*fourth revision*)
2004-1978	Carbon steel forgings for general engineering purposes
2611-1964	Carbon chromium molybdenum steel forgings for high temperature service
3261-1966	Carbon steel forgings for shipbuilding industry
3445-1966	Forged steel rolls
3469 (Parts I to III)-1974	Tolerances for closed die steel forgings
3479-1969	General requirements for steel drop, upset and press forgings
4367-1967	Alloy and tool steel forgings for general industrial use
4368-1967	Alloy steel billets, blooms and slabs for forgings for general engineering purposes